Extra Slides for

QCD Resummation: Direct and Effective Methods

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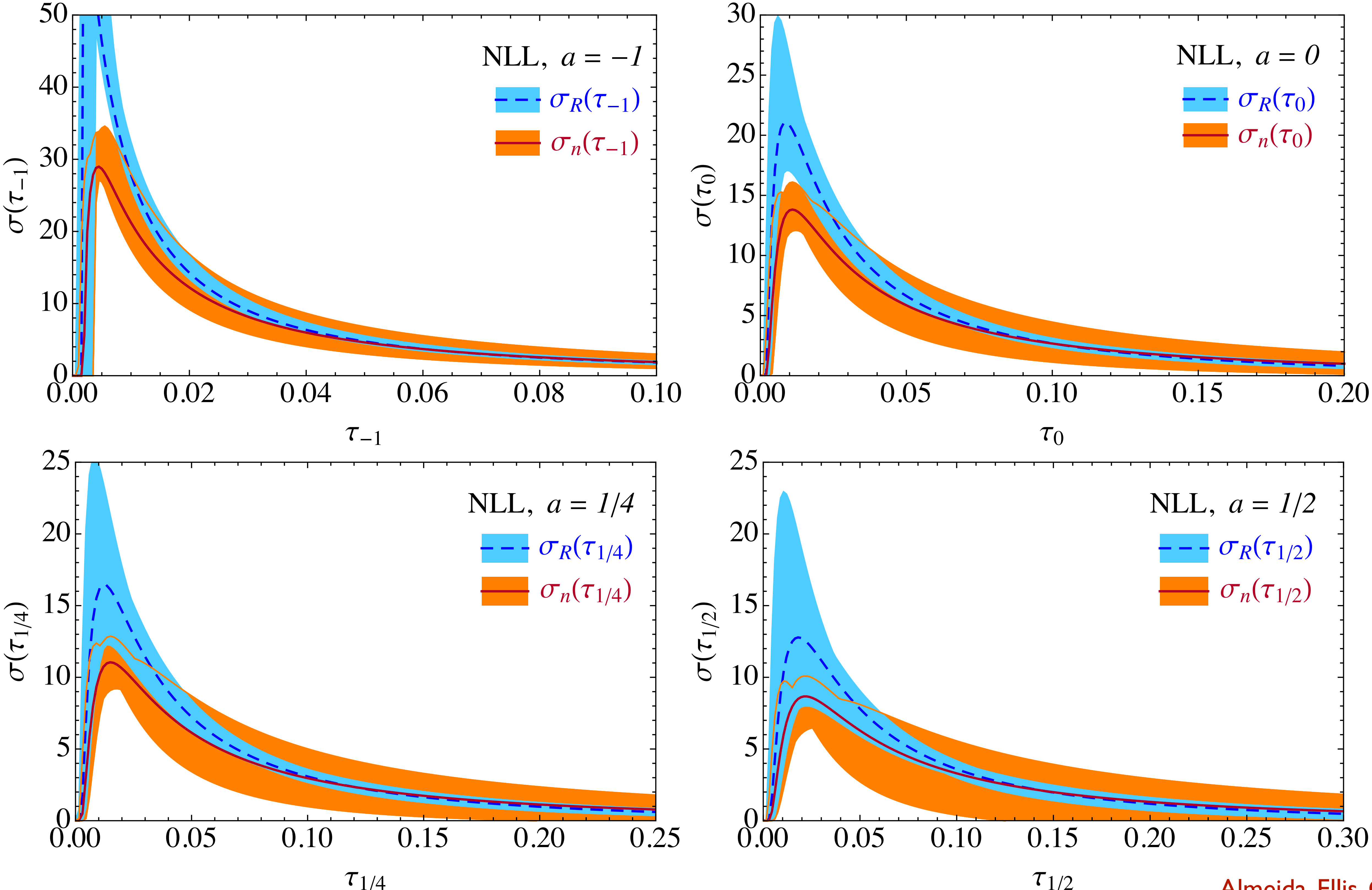
2nd Boston Jet Physics Workshop



Almeida, Ellis, CL, Sterman, Sung, Walsh [1401.4460]

N.B. Uncertainty estimates nominal:
canonical scales (no profiles), simple variation by factors of 2

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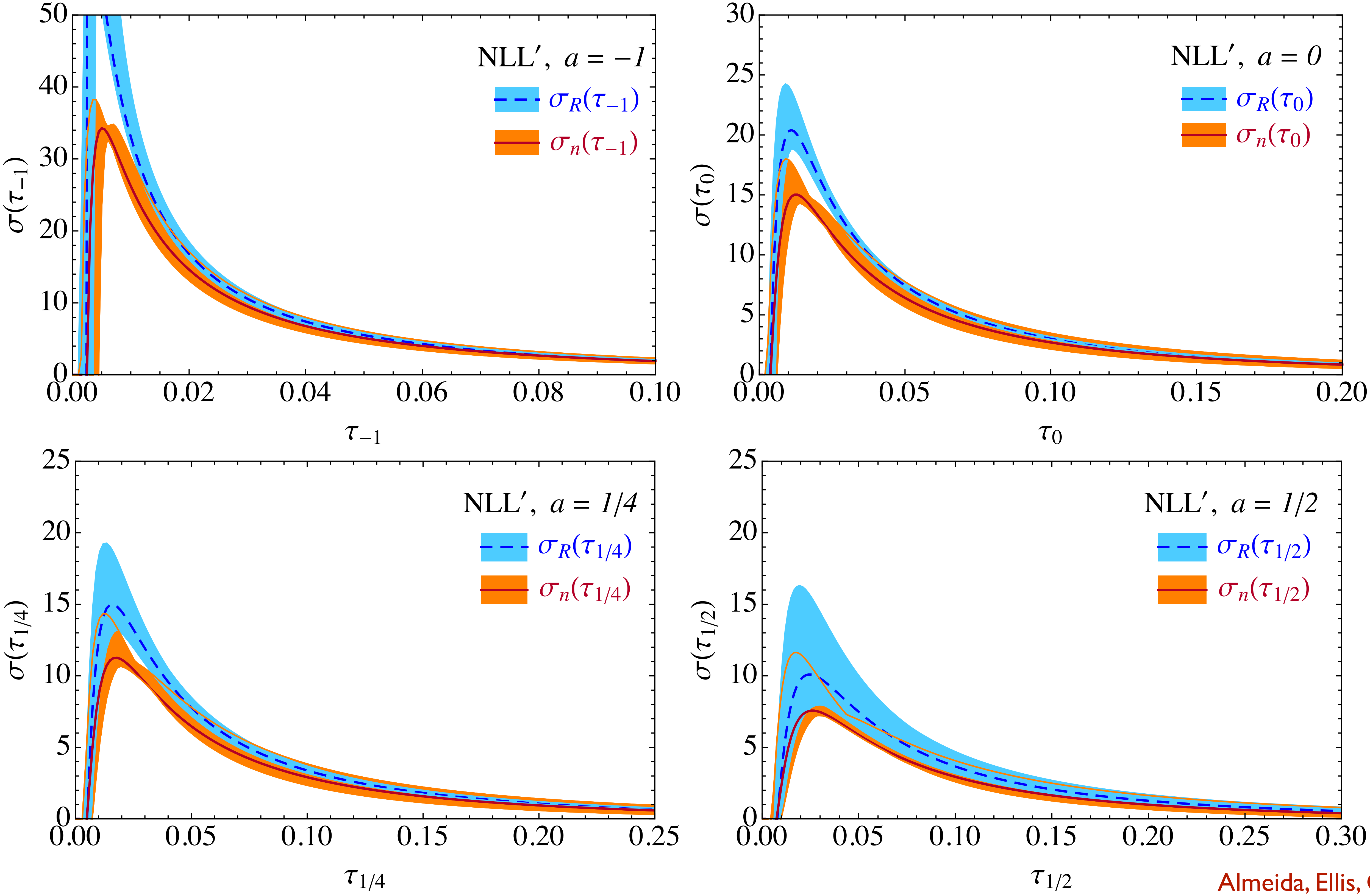

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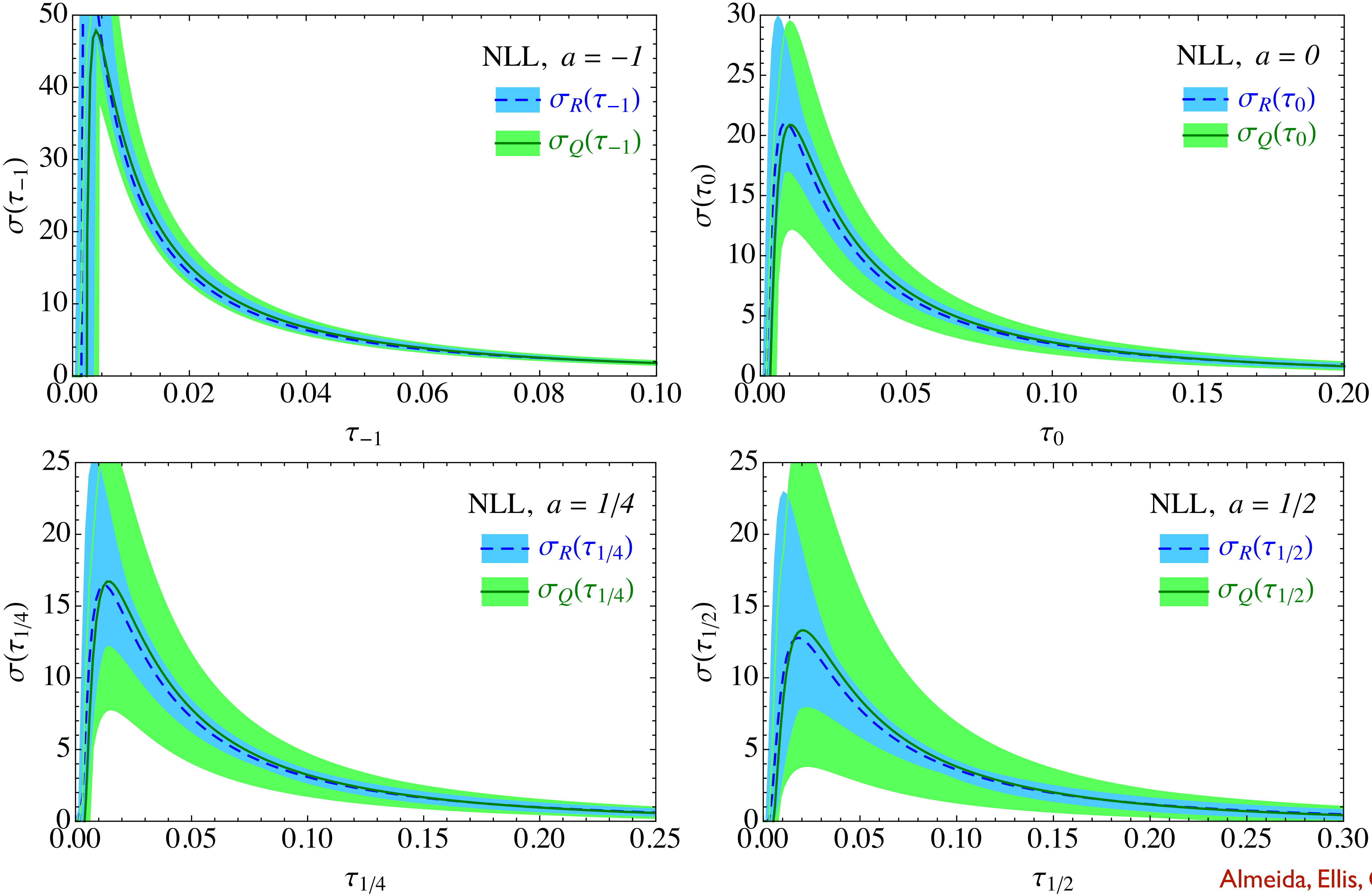

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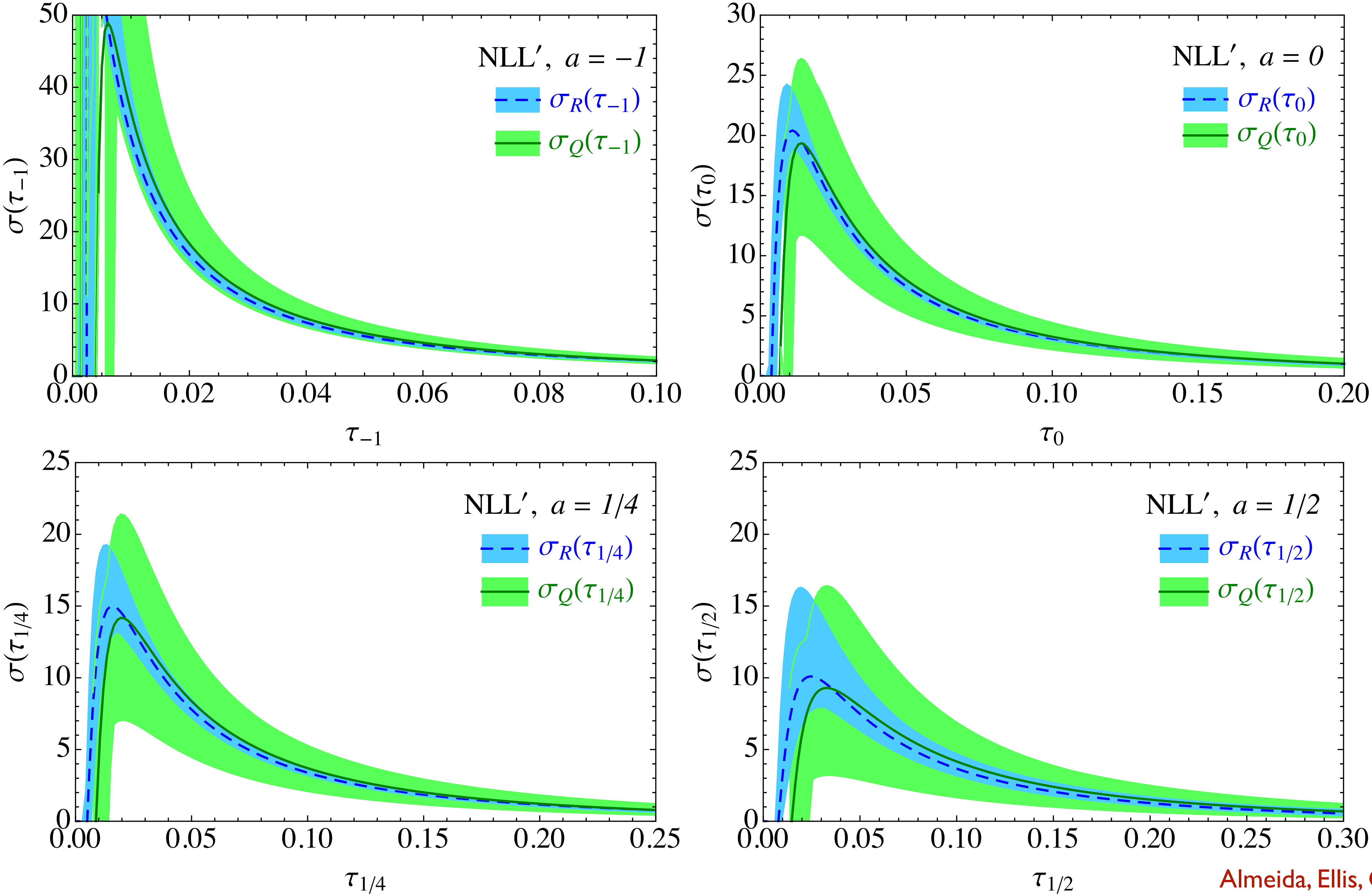

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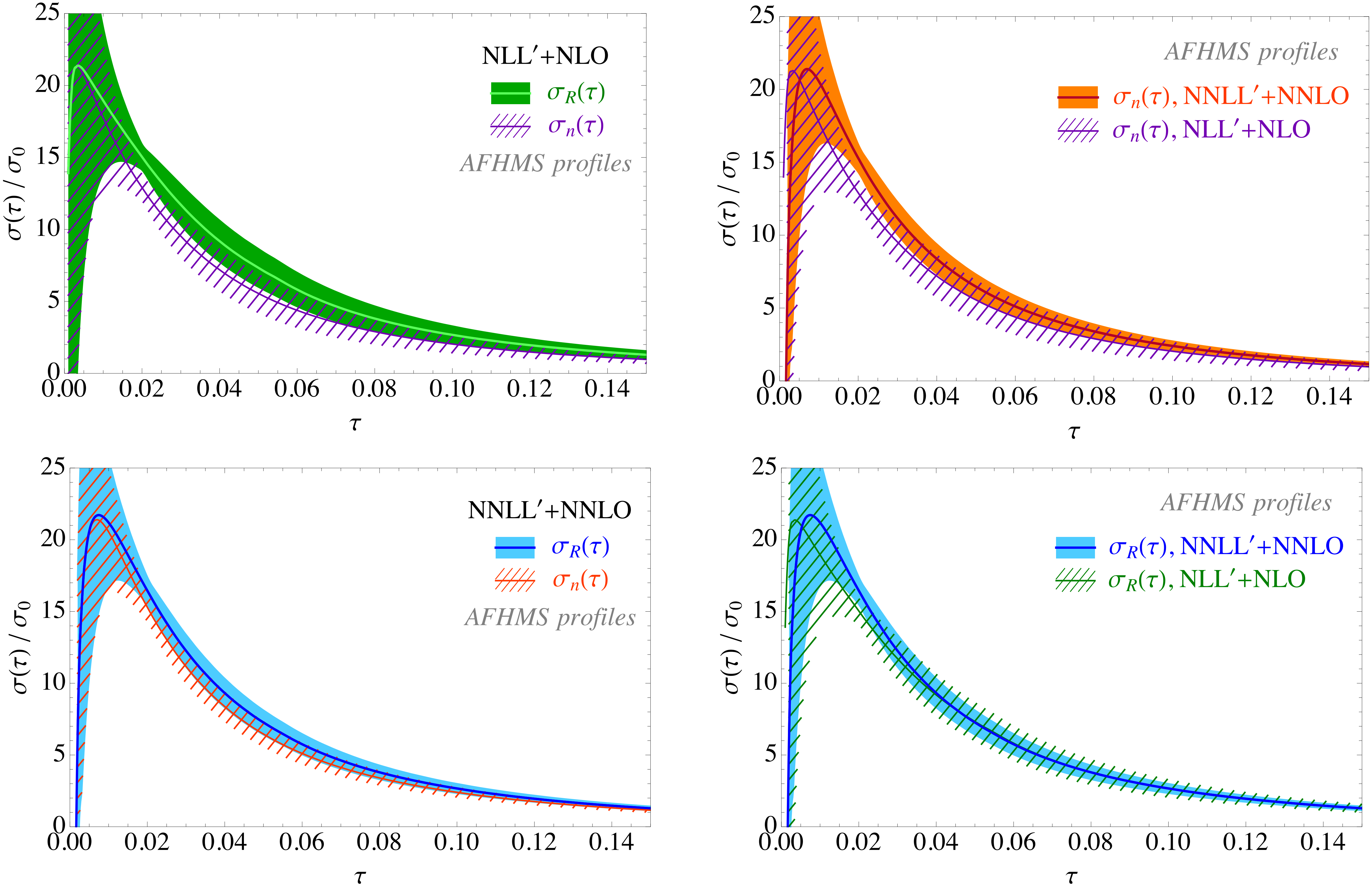

Using scale profiles from Abbate, Fickinger, Hoang, Mateu, Stewart (2010)

σ_R exhibits better convergence than σ_n order to order

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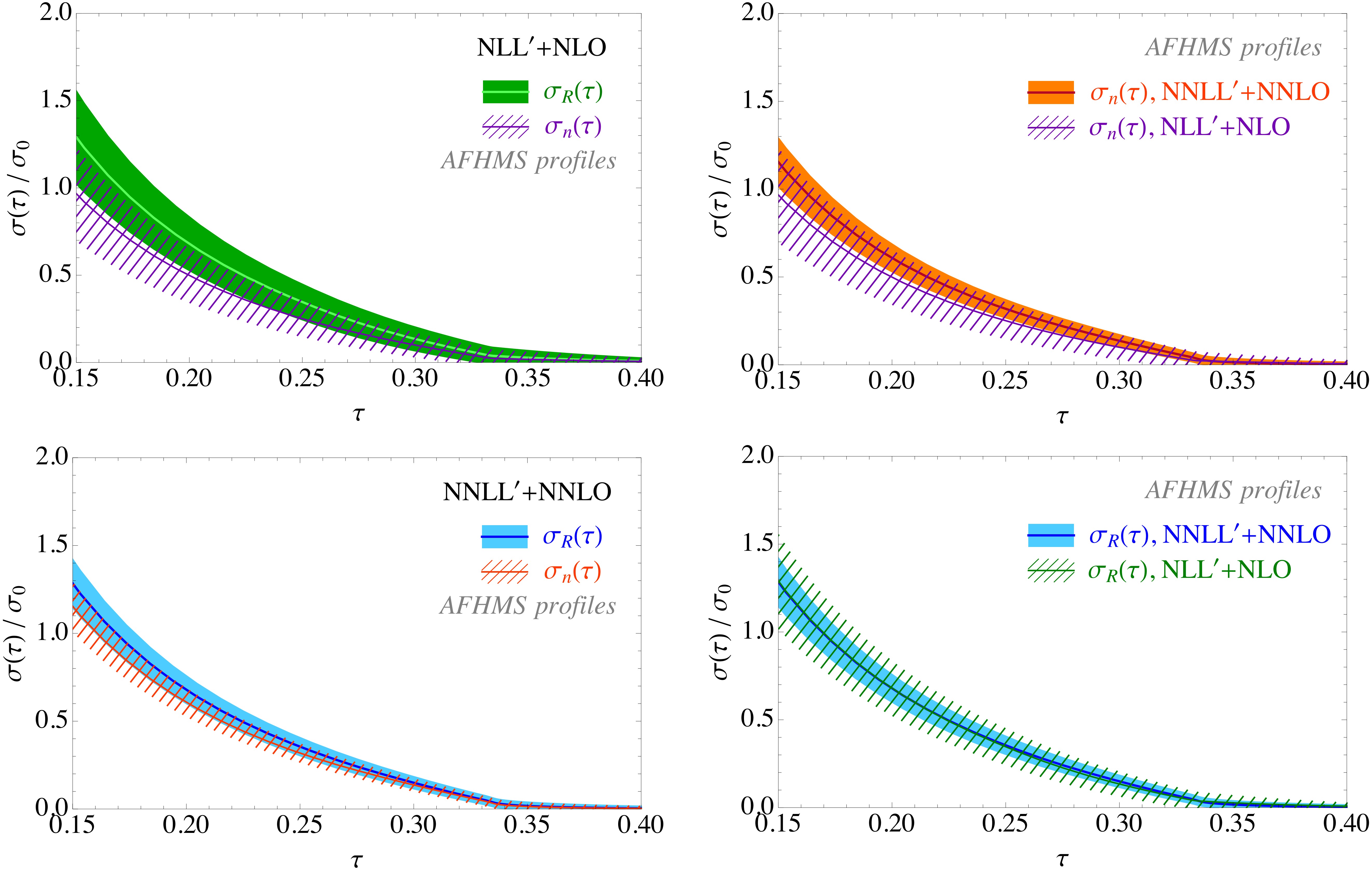

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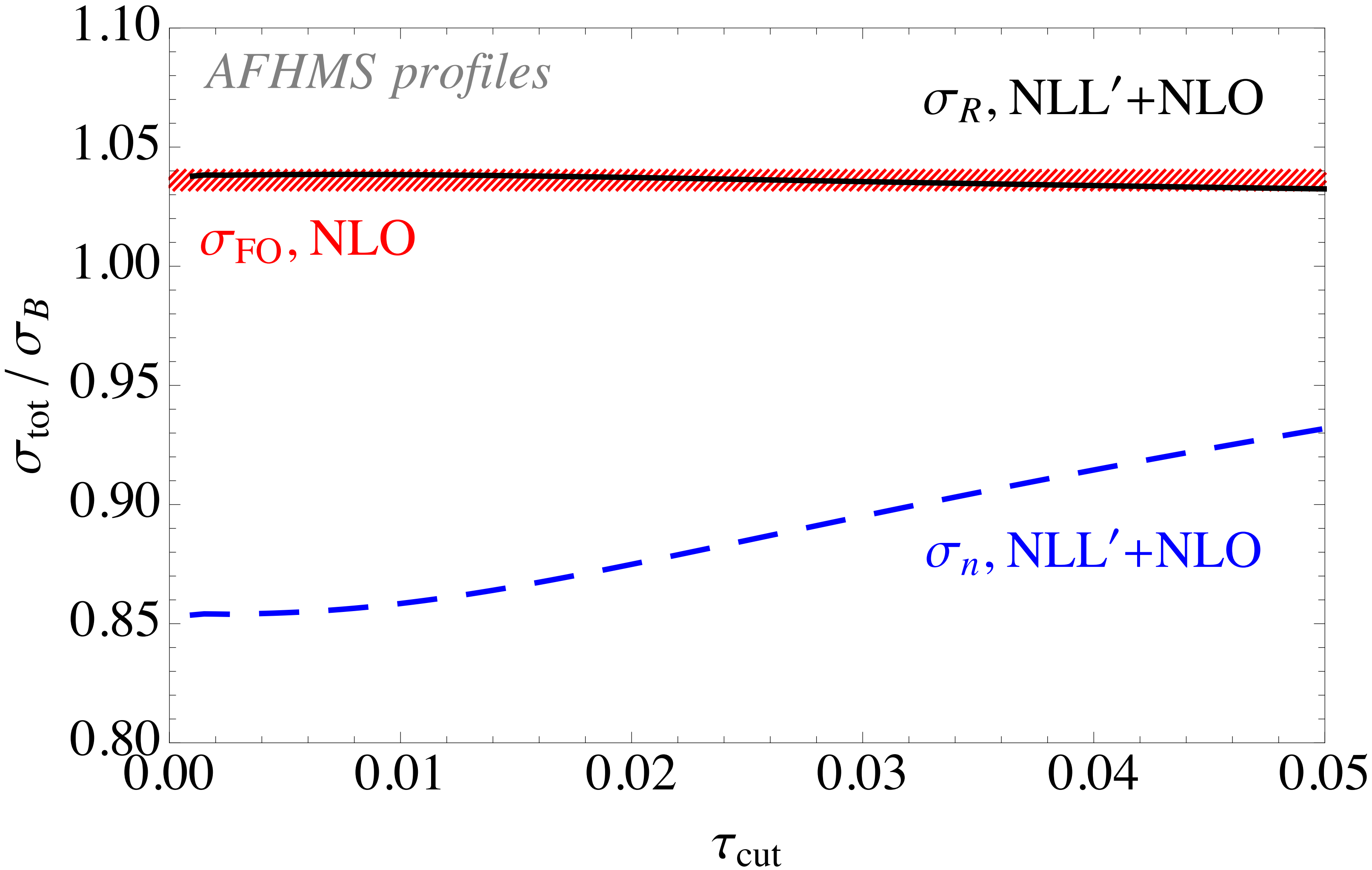
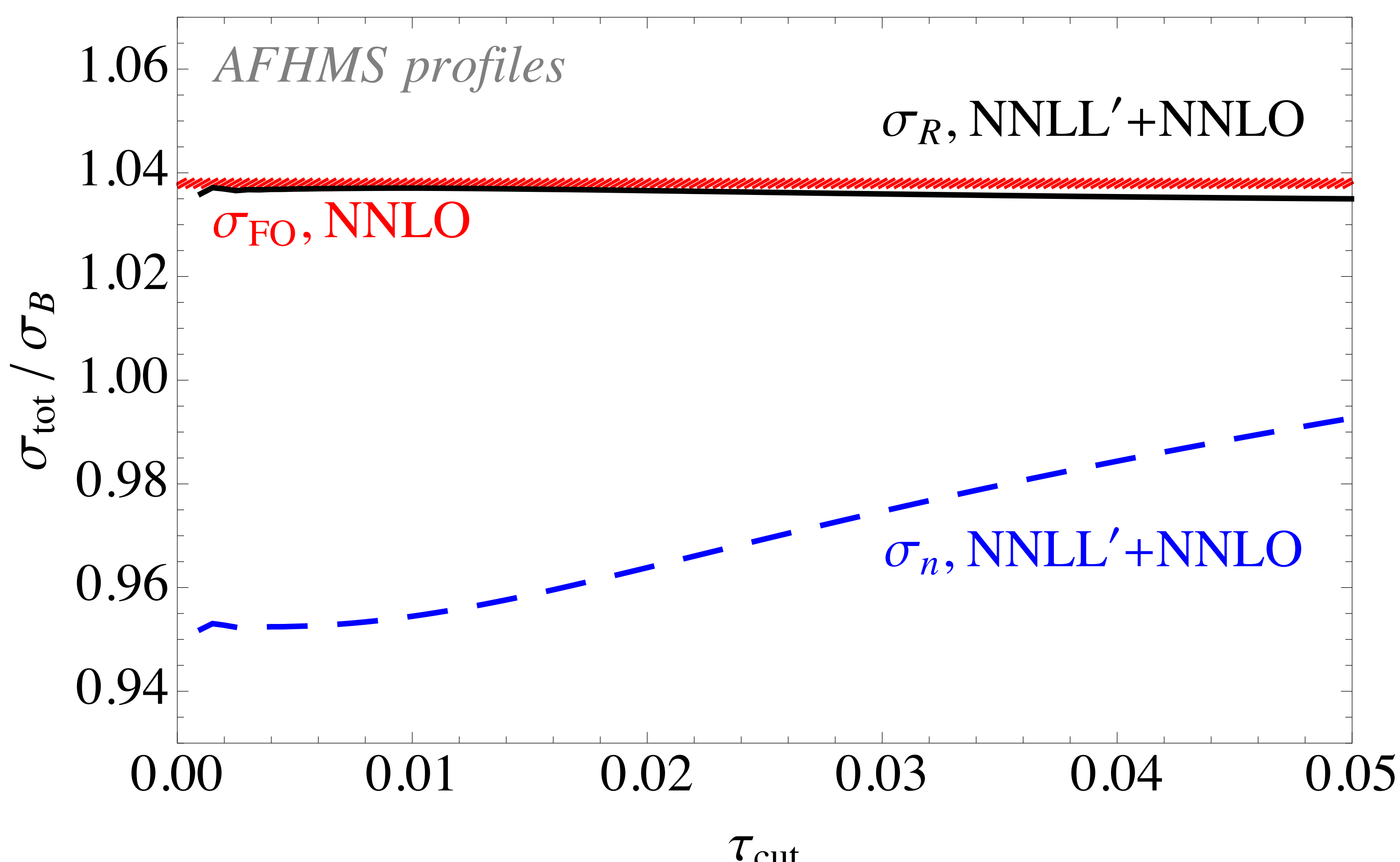


$$\sigma_{\rm tot} = R(\tau_{\rm cut}) + \int_0^{\tau_{\rm cut}} d\tau' \sigma(\tau')$$

σ_R integrates properly to the total cross section, more stable under variations of $\tau_{\rm cut}$



I. Compare SCET vs. factorization-based resummations: angularities.

- **One of a set of side-by-side calculations based on:**

  1. **Factorized cross sections in pQCD**
  2. **Scet treatments**

- e^+e^- **event shapes: angularities of** $a < 1$

$$\tau_a = \sum_{i \in jet} |p_{T,i}| \, e^{-|\eta_i|\,(1-a)}$$

- **Also: "Threshold" resummation of corrections for:**

  - **Drell-Yan (W, Z, H)**
  - **Direct photon**
  - **Heavy quark: total and differential in** $\vec{p}$.

- **Motivations . . .**

- **Do the resummed/scet treatments give same different predictions, formally equivalent but different in implementation, or what?**
- **Can we learn something by comparing them? Extensions to other processes?**
- **What are our best predictions?**
- **The "factorized list is longer so far – Drell-Yan Q_T, inclusive jets, dihadrons . . . serious comparison may facilitate progress.**

Slides from G. Sterman SCET & Jets Working Group Summary
Joint Theoretical-Experimental Workshop on Jets and Jet Substructure at the LHC
University of Washington, Jan. 11-15, 2010

- **From Hornig, Lee Ovanesyan (2009) for angularities: comparing NLL calculations (Chris Lee's talk)**

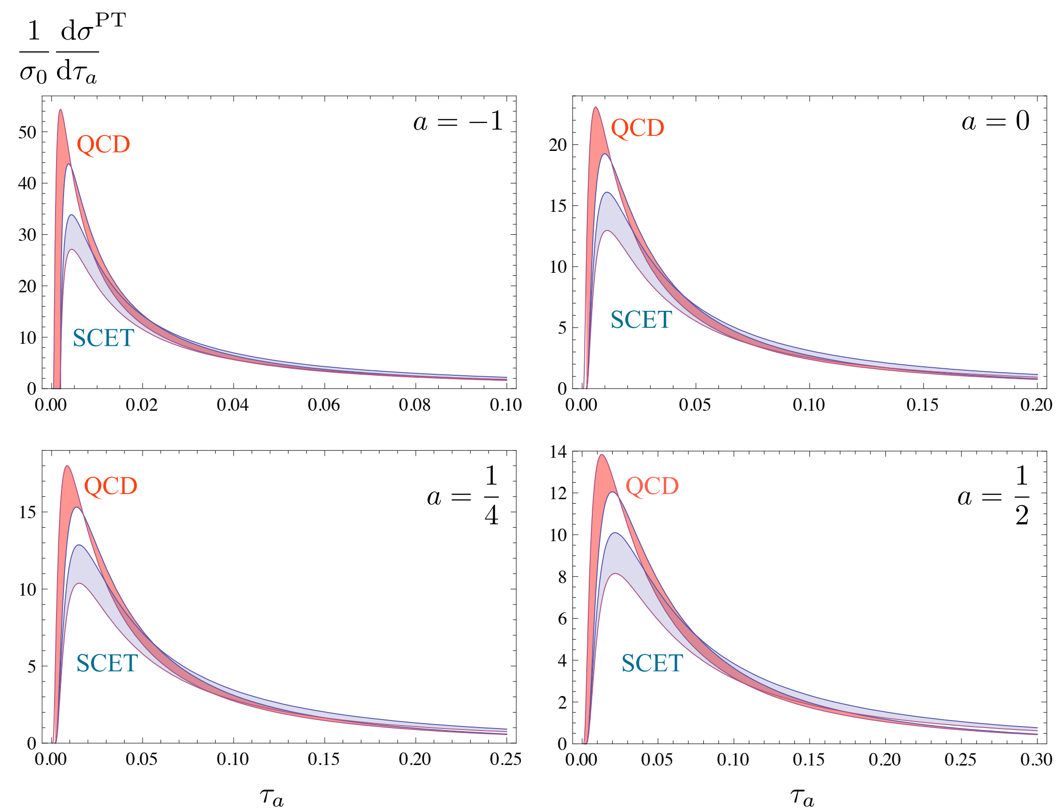


Figure 10: Factorization scale μ variation of the (unmatched, partonic) SCET NLL/LO (light blue band) and the classic QCD NLL/LO (red band) resummed results for angularity distributions. μ is varied over the range $\frac{Q}{2} \leq \mu \leq 2Q$ with $Q = 100$ GeV for the cases $a = -1$, $a = 0$, $a = 1/4$, and $a = 1/2$. To make a direct comparison to the QCD results, the scales in the SCET results have been chosen as $\mu = \mu_H = Q$, $\mu_J = Q\tau_a^{1/(2-a)}$, and $\mu_S = Q\tau_a$.

- **Where does the difference come from?**

- **The plot compares (well, George thinks) – not sophisticated matchings – the formulas:**
- **SCET NLL version of:** **(Hornig, Lee, Ovanesyan)**

4.3 Full distribution at NLL

By running the hard, jet, and soft functions from the scales $\mu_0 = \mu_H$, μ_J, and μ_S, respectively, to the common factorization scale μ and performing the convolution in Eq. (2.13) (see Appendix B for details), we find for the final resummed expression for the two-jet angularity distribution with NLL/NLO perturbative accuracy

$$\frac{1}{\sigma_0}\frac{d{\sigma_2}^{\mathrm{PT}}}{d\tau_a}\bigg|_{\mathrm{NLL/NLO}} = \left[\left(1 + f_H + 2f_J + f_S\right)U_a^\sigma(\tau_a;\mu,\mu_H,\mu_J,\mu_S)\right]_+ , \tag{4.27}$$

where we defined

$$U_a^\sigma(\tau_a;\mu,\mu_H,\mu_J,\mu_S) \equiv \frac{e^{K+\gamma_E\Omega}}{\Gamma(-\Omega)}\left(\frac{\mu_H}{Q}\right)^{\omega_H}\left(\frac{\mu_J}{Q}\right)^{2j_J\omega_J}\left(\frac{\mu_S}{Q}\right)^{j_S\omega_S}\left(\frac{\theta(\tau_a)}{{\tau_a}^{1+\Omega}}\right), \tag{4.28}$$

where

$$\Omega \equiv 2\,\omega_J(\mu,\mu_J) + \omega_S(\mu,\mu_S) \tag{4.29}$$

$$K \equiv K_H(\mu,\mu_H) + 2K_J(\mu,\mu_J) + K_S(\mu,\mu_S)\,, \tag{4.30}$$

- **PQCD NLL version of:** **(Berger, GS)**

$$\frac{1}{\sigma_0}\frac{d\sigma}{d\tau_a} = \frac{1}{\Gamma(-E'(1/\tau_a))}\; e^{-E(1/\tau_a)}\,,$$

with $E(1/\tau_a)$ given by $E(\nu)$ in:

The NLL resummed cross section (2.8) for $a < 1$ in moment space can be written as [18]

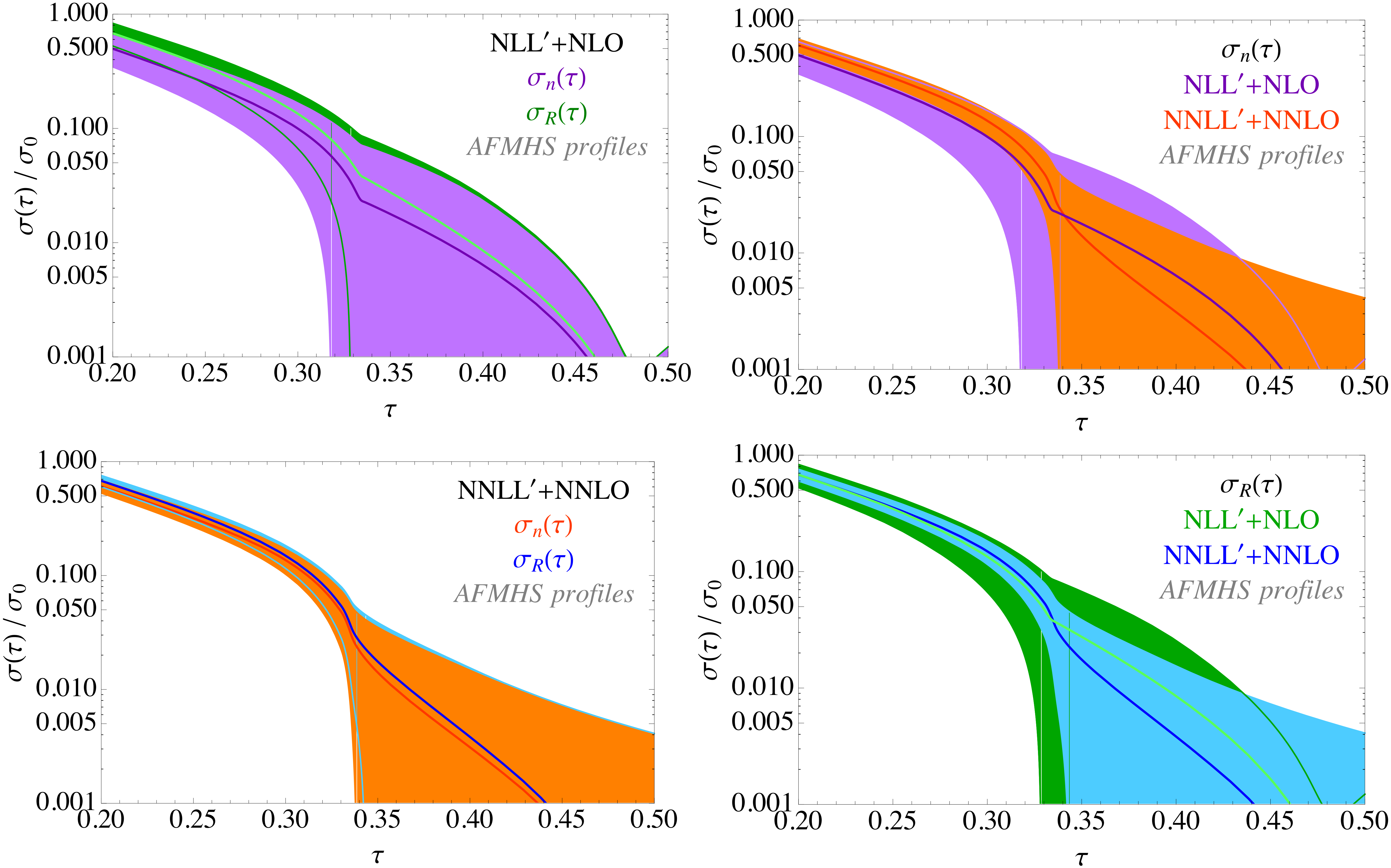
$$\begin{aligned}\frac{1}{\sigma_{\rm tot}}\,\tilde\sigma\,(\nu,Q,a) = \exp\Big\{2\int_0^1 \frac{du}{u}\Big[\int_{u^2Q^2}^{uQ^2}\frac{dp_T^2}{p_T^2}A\,(\alpha_s(p_T))\left({\rm e}^{-u^{1-a}\nu(p_T/Q)^a}-1\right)\\ +\frac{1}{2}B\left(\alpha_s(\sqrt{u}Q)\right)\left({\rm e}^{-u(\nu/2)^{2/(2-a)}}-1\right)\Big]\Big\}\\ \equiv [\,\mathcal{J}(\nu,Q,a)]^2\,, \qquad (3.1)\end{aligned}$$

- **What we've seen so far:**
- **At NLL, when expressed as an integral over the running coupling, the two are *exactly* the same formulas; things like**

$$\int_{Q\tau^{1/(2-a)}}^{Q} \frac{d\mu}{\mu} A(\alpha_s(\mu)) \ln\left[\frac{\mu}{Q}\right]$$

- **Could the difference be different implementations of running α_s? Is not a "Landau pole" issue as long as τ isn't small.**
- **Clearly, have to look more closely here, and then run down the gamut of other applications**

CL, Walsh [preliminary]



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